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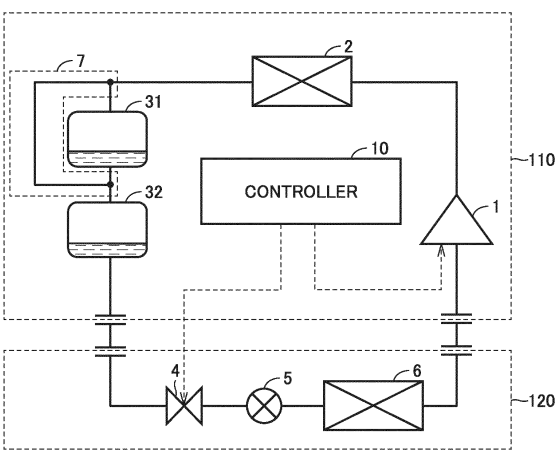
(54) REFRIGERATION CYCLE DEVICE

(57) In a refrigeration cycle apparatus (100), refrigerant circulates. The refrigeration cycle apparatus (100) comprises a compressor (1), a first heat exchanger (2), a second heat exchanger (6), a first receiver (31), a second receiver (32), a first valve (4), an expansion valve (5), and a bypass unit (7). The first receiver (31) and the second receiver (32) store the refrigerant in the form of liquid. The refrigerant circulates through the compressor (1), the first heat exchanger (2), the first receiver (31), the second receiver (32), the first valve (4), the expansion valve (5), and the second heat exchanger (6) in this order. The bypass unit (7) guides the refrigerant from the first heat exchanger (2) to the second receiver (32) without passing the refrigerant through the first receiver (31).

FIG.1

100



EP 4 071 424 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a refrigeration cycle apparatus comprising a receiver configured to store refrigerant of liquid (or a liquid refrigerant).

BACKGROUND ART

[0002] A conventionally known refrigeration cycle apparatus comprises a receiver configured to store a liquid refrigerant. For example, Japanese Utility Model Laying-open No. 62-204253 (PTL 1) discloses a liquid receiver used in a refrigeration cycle system having one compressor and one condenser. The liquid receiver has a body with two liquid reservoirs formed therein and communicating with each other over an upper edge of a shield plate. The condenser outputs refrigerant in a gas-liquid two-phase state which in turn flows into one liquid reservoir and then flows over the upper edge of the shield plate into the other liquid reservoir. The liquid receiver allows gas-liquid separation of refrigerant to be done satisfactorily.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: Japanese Utility Model Laying-open No. 62-204253

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] In a refrigeration cycle apparatus, an operation to move refrigerant that flows through a channel (on a low-pressure side) between an expansion valve and a suction port of a compressor to a channel (on a high-pressure side) between a discharge port of the compressor and the expansion valve (i.e., a pump-down operation) may be performed. As a result of the pump-down operation, an amount of liquid refrigerant stored in a receiver connected between the condenser and the expansion valve increases.

[0005] When liquid refrigerant having a degree of supercooling flows into the receiver from the condenser, refrigerant in the form of gas (or a gaseous refrigerant) in the receiver is cooled by the liquid refrigerant and stored in the receiver as saturated liquid. That is, in order to increase the amount of liquid refrigerant stored in the receiver, liquid refrigerant having a degree of supercooling needs to flow into the receiver.

[0006] When the pump-down operation is performed in a refrigeration cycle apparatus in which two liquid reservoirs (or receivers) that store liquid refrigerant communicate in series, as in the receiver disclosed in PTL 1, saturated liquid having no degree of supercooling flows out of the receiver closer to the condenser until the amount of liquid refrigerant stored in the receiver reaches an upper limit amount. Therefore, until the amount of liquid refrigerant stored in the receiver reaches the upper limit amount, the amount of liquid refrigerant stored in the other receiver substantially does not increase. If pressure of refrigerant on the high-pressure side excessively increases before the amount of the liquid refrigerant stored in the receiver closer to the condenser reaches the upper limit amount, and it becomes difficult to continue operation of the compressor, the pump-down operation cannot be completed.

[0007] The present invention has been made in order to solve the above-described problem, and an object of the present invention is to improve the pump-down operation in stability.

SOLUTION TO PROBLEM

[0008] In a refrigeration cycle apparatus according to the present invention, refrigerant circulates. The refrigeration cycle apparatus comprises a compressor, a first heat exchanger, a second heat exchanger, a first receiver, a second receiver, a first valve, an expansion valve, a second heat exchanger, and a bypass unit. The first receiver and the second receiver store the refrigerant in the form of liquid. The refrigerant circulates through the compressor, the first heat exchanger, the first receiver, the second receiver, the first valve, the expansion valve, and the second heat exchanger in this order. The bypass unit receives the refrigerant from the first heat exchanger and guides the received refrigerant to the second receiver without passing the refrigerant through the first receiver.

ADVANTAGEOUS EFFECTS OF INVENTION

[0009] The refrigeration cycle apparatus of the present invention allows the bypass unit to guide refrigerant from the first heat exchanger to the second receiver without passing the refrigerant through the first receiver, and can thus enhance a pump-down operation in stability.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

Fig. 1 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to a first embodiment.

Fig. 2 is a functional block diagram showing a configuration of a controller of Fig. 1.

Fig. 3 is a functional block diagram showing a state of a channel of the refrigeration cycle apparatus of Fig. 1 in a pump-down operation.

Fig. 4 is a flowchart of a process performed by the controller of Fig. 1 when a condition for starting the pump-down operation is established.

Fig. 5 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to a comparative example.

Fig. 6 is a timing plot representing how an amount of liquid refrigerant stored in a receiver in the pump-down operation (or a storage rate) varies with time.

Fig. 7 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to a second embodiment.

Fig. 8 is a functional block diagram showing a state of a channel of the refrigeration cycle apparatus of Fig. 7 in a pump-down operation.

Fig. 9 is a flowchart of a process performed by the controllers shown in Figs. 7 and 8.

Fig. 10 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to a first modified example of the second embodiment.

Fig. 11 is a flowchart of a process performed by the controllers shown in Fig. 10.

Fig. 12 is a functional block diagram showing a configuration of a refrigeration cycle apparatus according to a second modified example of the second embodiment.

Fig. 13 is a flowchart of a process performed by the controllers shown in Fig. 12.

DESCRIPTION OF EMBODIMENTS

[0011] Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings. In the figures, identical or corresponding components are identically denoted and will not be described redundantly in principle.

First Embodiment

[0012] Fig. 1 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 100 according to a first embodiment. Examples of refrigeration cycle apparatus 100 include refrigerators, air conditioners, and showcases. Refrigeration cycle apparatus 100 selectively performs a normal operation and a pump-down operation. Fig. 1 shows a state of a channel of refrigeration cycle apparatus 100 in the normal operation.

[0013] As shown in Fig. 1, refrigeration cycle apparatus 100 comprises an outdoor unit 110 and an indoor unit 120. Indoor unit 120 is disposed in a space to be cooled (a second space). Outdoor unit 110 is disposed in a space (a first space) outside the space to be cooled.

[0014] Outdoor unit 110 includes a compressor 1, a condenser 2 (a first heat exchanger), a receiver 31 (a first receiver), a receiver 32 (a second receiver), a bypass unit 7, and a controller 10. Indoor unit 120 includes an on/off valve 4 (a first valve), an expansion valve 5 (an expansion valve), and an evaporator 6 (a second heat exchanger). In refrigeration cycle apparatus 100, refrigerant circulates through compressor 1, condenser 2, receiver 31, receiver 32, on/off valve 4, expansion valve 5, and evaporator 6 in this order. Expansion valve 5 is, for example, a thermal expansion valve.

[0015] Receivers 31 and 32 store liquid refrigerant. Receiver 31 receives refrigerant from condenser 2. Bypass unit 7 receives refrigerant from condenser 2 and guides the refrigerant to receiver 32 without passing the refrigerant through receiver 31. Receiver 32 receives refrigerant of saturated liquid from receiver 31 and also receives refrigerant from condenser 2.

[0016] When a small-capacity receiver used in a refrigeration cycle apparatus of another model is used as receivers 31 and 32 and receivers 31 and 32 are in communication with each other in series between condenser 2 and expansion valve 5, the receivers can be common with the other model and a dedicated receiver having a large capacity can be dispensed with. As a result, refrigeration cycle apparatus 100 can be manufactured at a reduced cost.

[0017] Controller 10 controls a driving frequency for compressor 1 to control an amount of refrigerant discharged by compressor 1 per unit time. Controller 10 opens on/off valve 4 in the normal operation. Controller 10 may be disposed in indoor unit 120, or may be disposed in a location other than outdoor unit 110 and indoor unit 120. A controller may be disposed for each of outdoor unit 110 and indoor unit 120.

[0018] Fig. 2 is a functional block diagram showing a configuration of controller 10 shown in Fig. 1. Fig. 2 also shows a configuration of a controller 20 shown in Fig. 7 and described hereinafter. As shown in Fig. 2, controller 10 (20) includes circuitry 11 (21), a memory 12 (22), and an input/output unit 13 (23). Processing circuitry 11 (21) may be dedicated hardware or may be a CPU (Central Processing Unit) that executes a program stored in memory 12 (22). When circuitry 11 (21) is dedicated hardware, circuitry 11 (21) may for example be a single circuit, a composite circuit, a programmed processor, a parallel programmed processor, an ASIC (an Application Specific Integrated Circuit), an FPGA (a Field Programmable Gate Array), or a combination thereof. When circuitry 11 (21) is a CPU, controller 10 (20) has functionality implemented by software, firmware, or a combination of software and firmware. The software or firmware is described as a program and stored in memory 12 (22). Processing circuitry 11 (21) reads and executes a program stored in memory 12 (22). Memory 12 (22) includes a nonvolatile or volatile semiconductor memory (for example, RAM (Random Access Memory), ROM (Read Only Memory), flash memory, EPROM (Erasable Programmable Read Only Memory) or EEPROM (Electrically Erasable Programmable Read Only Memory)), and a magnetic disk, a flexible disk, an optical disk, a compact disk, a mini disk, or a DVD (Digital Versatile Disc). Note that the CPU is also referred to as a central processing unit, a processing unit, an arithmetic unit, a microprocessor, a microcomputer, a processor, or a DSP (Digital Signal Processor).

[0019] Input/output unit 13 (23) receives an operation from a user and outputs a processing result to the user. Input/output unit 13 (23) includes, for example, a mouse, a keyboard, a touch panel, a display, and a speaker.

[0020] Fig. 3 is a functional block diagram showing a state of a channel of refrigeration cycle apparatus 100 of Fig. 1 in a pump-down operation. The pump-down operation is performed, for example, when a condition for stopping compressor 1 is established. A difference from the state shown in Fig. 1 is that on/off valve 4 is closed. The remainder is similar, and accordingly, will not be described repeatedly.

[0021] Fig. 4 is a flowchart of a process performed by controller 10 of Fig. 1 when a condition for starting the pump-down operation is established. The process shown in Fig. 4 is invoked by a main routine (not shown) that generally controls refrigeration cycle apparatus 100. Hereinafter, a step will simply be indicated by S.

[0022] As shown in Fig. 4, controller 10 closes on/off valve 4 in S101 and proceeds to S102. Controller 10 waits for a fixed period of time in S102. For the fixed period of time, liquid refrigerant having a degree of supercooling flows from condenser 2 into each of receivers 31 and 32, and gaseous refrigerant included in each of receivers 31 and 32 is liquefied. As a result, an amount of liquid refrigerant stored in each of receivers 31 and 32 increases. After the fixed period of time elapses, controller 10 performs a step to end the pump-down operation in S103, and returns the process to the main routine. The step of ending the pump-down operation includes, for example, stopping compressor 1.

[0023] Fig. 5 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 900 according to a comparative example. Refrigeration cycle apparatus 900 has the configuration of refrigeration cycle apparatus 100 shown in Fig. 3 minus bypass unit 7. The remainder is similar, and accordingly, will not be described repeatedly.

[0024] Fig. 6 is a timing plot representing how an amount of liquid refrigerant stored in receivers 31 and 32 in the pump-down operation (or a storage rate) varies with time. Fig. 6(a) is a timing plot during a pump-down operation of refrigeration cycle apparatus 900 of Fig. 5, and Fig. 6(b) is a timing plot during a pump-down operation of refrigeration cycle apparatus 100 of Fig. 3. In each of Figs. 6(a) and 6(b), receiver 31 has a storage rate, as indicated by a solid line, and receiver 32 has a storage rate, as indicated by a dotted line.

[0025] As shown in Fig. 6(a), the pump-down operation starts at time t10. The storage rate of receiver 31 increases from time t10 and reaches 100% at time t11. For a period of time from time t10 to time t11, receiver 31 outputs refrigerant of saturated liquid, and accordingly, gaseous refrigerant in receiver 32 is substantially unliquefied. Therefore, receiver 32 has a storage rate substantially unchanged for the period of time from time t10 to time t11. After time t11, receiver 31 outputs liquid refrigerant having a degree of supercooling and the liquid refrigerant flows into receiver 32, and receiver 32 thus has an increasing storage rate. The pump-down operation ends at time t12. A period of time required for the pump-down operation is a time interval from time t10 to time t12.

[0026] As shown in Fig. 6(b), a pump-down operation starts at time t0. Once the pump-down operation has been started, receivers 31 and 32 each receive liquid refrigerant having a degree of supercooling from condenser 2, and receivers 31 and 32 thus each have an increasing storage rate. The pump-down operation ends at time t1. A period of time required for the pump-down operation is a time interval from time t0 to time t1 and is thus shorter than the time interval from time t10 to time t12 shown in Fig. 6(a).

[0027] Refrigeration cycle apparatus 100 can increase an amount of liquid refrigerant stored in each of receivers 31 and 32 once the pump-down operation is started, and refrigeration cycle apparatus 100 can thus make the pump-down operation shorter than when an amount of liquid refrigerant stored increases in the order of receiver 31 followed by receiver 32. This ensures that the pump-down operation is completed before pressure on the high-pressure side excessively increases.

[0028] The refrigeration cycle apparatus according to the first embodiment can thus improve the pump-down operation in stability.

Second Embodiment

[0029] In the first embodiment, the bypass unit guides refrigerant from the condenser to the receiver closer to the expansion valve in both the normal operation and the pump-down operation. In the second embodiment, a configuration in which the bypass unit is closed in the normal operation and opened in the pump-down operation will be described.

[0030] Fig. 7 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 200 according to the second embodiment. Fig. 7 shows a state of a channel of refrigeration cycle apparatus 200 in the normal operation. As shown in Fig. 7, refrigeration cycle apparatus 200 comprises an outdoor unit 210 and an indoor unit 220. Outdoor unit 210 is configured such that the Fig. 1 bypass unit 7 and controller 10 are replaced with a bypass unit 70 and a controller 20, respectively, and temperature sensors Ts1 and Ts2 are added. Bypass unit 70 is the Fig. 1 bypass unit 7 plus a bypass valve 71 (a second valve) in configuration. Indoor unit 220 is the Fig. 1 indoor unit 120 plus a controller 30 in configuration. The remainder is identical, and accordingly, will not be described repeatedly.

[0031] As shown in Fig. 7, bypass valve 71 is connected between condenser 2 and receiver 32. Controller 20 closes bypass valve 71 in the normal operation. Controller 20 obtains from temperature sensor Ts1 a temperature T1 of refrigerant passing between receiver 32 and on/off valve 4. Controller 20 obtains from temperature sensor Ts2 a temperature T2 of a space in which outdoor unit 210 is disposed. Controller 20 controls a driving frequency for compressor 1 to control an amount of refrigerant discharged by compressor 1 per unit time. Controller 30 opens on/off valve 4 in the normal operation. No electrical communication line is established between controllers 20 and 30.

[0032] Fig. 8 is a functional block diagram showing a state of a channel of refrigeration cycle apparatus 200 of Fig. 7 in a pump-down operation. As shown in Fig. 8, controller 30 closes on/off valve 4. When on/off valve 4 is closed, there is no substantial flow of refrigerant through a channel between receiver 32 and on/off valve 4. Therefore, when on/off valve 4 is closed, the refrigerant has temperature T1 approaching temperature T2 of the space in which outdoor unit 210 is disposed. Accordingly, when a condition (a specific condition) that temperatures T2 and T1 have a difference having an absolute value smaller than a reference value $\delta 1$ is established, controller 20 determines that on/off valve 4 is closed, and controller 20 opens bypass valve 71. Reference value $\delta 1$ can be determined, as appropriate, through an actually conducted experiment or a simulation.

[0033] Fig. 9 is a flowchart of a process performed by controller 20 of Figs. 7 and 8. The process shown in Fig. 9 is invoked every sampling time by a main routine (not shown) that generally controls refrigeration cycle apparatus 200.

[0034] As shown in Fig. 9, controller 20 determines in S201 whether the condition that temperatures T2 and T1 have a difference having an absolute value smaller than reference value $\delta 1$ is established. When the absolute value is equal to or larger than reference value $\delta 1$ (NO in S201), controller 20 determines that on/off valve 4 is not closed, and controller 20 returns the process to the main routine. When the absolute value is smaller than reference value $\delta 1$ (YES in S201), controller 20 opens bypass valve 71 in S202 and proceeds to S203. Controller 20 waits for a fixed period of time in S203. For the fixed period of time, liquid refrigerant having a degree of supercooling flows from condenser 2 into each of receivers 31 and 32, and gaseous refrigerant included in each of receivers 31 and 32 is liquefied. As a result, an amount of liquid refrigerant stored in each of receivers 31 and 32 increases. After the fixed period of time elapses, controller 20 performs a step to end the pump-down operation in S204, and returns the process to the main routine. The step of ending the pump-down operation includes, for example, stopping compressor 1 and closing bypass valve 71.

[0035] A condition indicating that on/off valve 4 is closed is not limited to that indicated in Fig. 9 by S201. When on/off valve 4 is closed, an amount of refrigerant on the high-pressure side increases, and accordingly, pressure of refrigerant discharged from compressor 1 (an output pressure) increases. Therefore, a condition that compressor 1 outputs pressure increasing in an amount larger than a reference value per unit time can be used as the condition indicating that on/off valve 4 is closed.

[0036] Fig. 10 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 200A according to a first modified example of the second embodiment. Refrigeration cycle apparatus 200A is configured such that controller 20 of Fig. 8 is replaced with a controller 20A, temperature sensors Ts1 and Ts2 are eliminated, and a pressure sensor Ps1 is added. The remainder is identical, and accordingly, will not be described repeatedly.

[0037] As shown in Fig. 10, controller 20A obtains from pressure sensor Ps1 a pressure Pd output from compressor 1 (a pressure of refrigerant passing between compressor 1 and condenser 2). Controller 20A opens bypass valve 71 when a condition (a specific condition) is established that output pressure Pd increases in an amount larger than a reference value $\delta 2$ when an interval between two successive sampling times (a reference time interval) is defined as a unit time. Reference value $\delta 2$ can be determined, as appropriate, through an actually conducted experiment or a simulation.

[0038] Fig. 11 is a flowchart of a process performed by controller 20A of Fig. 10. The process shown in Fig. 11 is invoked every sampling time by a main routine (not shown) that generally controls refrigeration cycle apparatus 200A. S202 to S204 in Fig. 11 are the same as those in Fig. 9.

[0039] As shown in Fig. 11, in S211, controller 20A determines whether the condition that output pressure Pd increases in an amount larger than reference value $\delta 2$ per unit time is established. When the amount is equal to or less than reference value $\delta 2$ (NO in S211), controller 20A determines that on/off valve 4 is not closed, and controller 20A returns the process to the main routine. When the amount is larger than reference value $\delta 2$ (YES in S211), controller 20A performs S202 to S204, similarly as done in Fig. 9, and controller 20A returns the process to the main routine.

[0040] When on/off valve 4 is closed, an amount of refrigerant on the low-pressure side decreases, and accordingly, pressure of refrigerant sucked into compressor 1 (a suction pressure) decreases. Therefore, a condition that suction pressure of compressor 1 decreases in an amount larger than a reference value per unit time can also be used as the condition indicating that on/off valve 4 is closed.

[0041] Fig. 12 is a functional block diagram showing a configuration of a refrigeration cycle apparatus 200B according to a second modified example of the second embodiment. Refrigeration cycle apparatus 200B is configured such that controller 20 of Fig. 8 is replaced with a controller 20B, temperature sensors Ts1 and Ts2 are eliminated, and a pressure sensor Ps2 is added. The remainder is identical, and accordingly, will not be described repeatedly.

[0042] As shown in Fig. 12, controller 20B obtains from pressure sensor Ps2 a suction pressure Ps of compressor 1 (a pressure of refrigerant passing between evaporator 6 and compressor 1). Controller 20B opens bypass valve 71 when a condition (a specific condition) is established that suction pressure Ps decreases in an amount larger than a reference value δ3 when an interval between two successive sampling times is defined as a unit time. Reference value δ3 can be determined, as appropriate, through an actually conducted experiment or a simulation.

[0043] Fig. 13 is a flowchart of a process performed by controller 20B of Fig. 12. The process shown in Fig. 13 is invoked every sampling time by a main routine (not shown) that generally controls refrigeration cycle apparatus 200B. S202 to S204 in Fig. 13 are the same as those in Fig. 9.

[0044] As shown in Fig. 13, controller 20B determines in S221 whether the condition that suction pressure Ps decreases in an amount larger than reference value δ3 per unit time is established. When the amount is equal to or less than reference value δ3 (NO in S221), controller 20B determines that on/off valve 4 is not closed, and controller 20B returns the process to the main routine. When the amount is larger than reference value δ3 (YES in S221), controller 20B performs S202 to S204, similarly as done in Fig. 9, and controller 20B returns the process to the main routine.

[0045] The refrigeration cycle apparatus according to the second embodiment and the first and second modified examples can thus improve the pump-down operation in stability.

[0046] The embodiments disclosed herein are also intended to be combined within a consistent scope as appropriate and thus implemented. It should be understood that the embodiments disclosed herein have been described for the purpose of illustration only and in a non-restrictive manner in any respect. The scope of the present invention is defined by the terms of the claims, rather than the description above, and is intended to include any modifications within the meaning and scope equivalent to the terms of the claims.

REFERENCE SIGNS LIST

[0047] 1 compressor, 2 condenser, 4 on/off valve, 5 expansion valve, 6 evaporator, 7, 70 bypass unit, 10, 20, 20A, 20B, 30 controller, 11 circuitry, 12 memory, 13 input/output unit, 31, 32 receiver, 71 bypass valve, 100, 200, 200A, 200B, 900 refrigeration cycle apparatus, 110, 210 outdoor unit, 120, 220 indoor unit, Ps1, Ps2 pressure sensor, Ts1, Ts2 temperature sensor.

Claims

1. A refrigeration cycle apparatus in which refrigerant circulates, the refrigeration cycle apparatus comprising:

   a compressor;
   a first heat exchanger and a second heat exchanger;
   a first receiver and a second receiver configured to store the refrigerant in a form of liquid;
   a first valve;
   an expansion valve; and
   a bypass unit, wherein
   the refrigerant circulates through the compressor, the first heat exchanger, the first receiver, the second receiver, the first valve, the expansion valve, and the second heat exchanger in this order, and
   the bypass unit guides the refrigerant from the first heat exchanger to the second receiver without passing through the first receiver.

2. The refrigeration cycle apparatus according to claim 1, further comprising a controller configured to control the bypass unit, wherein

   the bypass unit includes a second valve connected between the first heat exchanger and the second receiver, and
   the controller opens the second valve when a specific condition indicating that the first valve is closed is established, and the controller closes the second valve when the specific condition is not established.

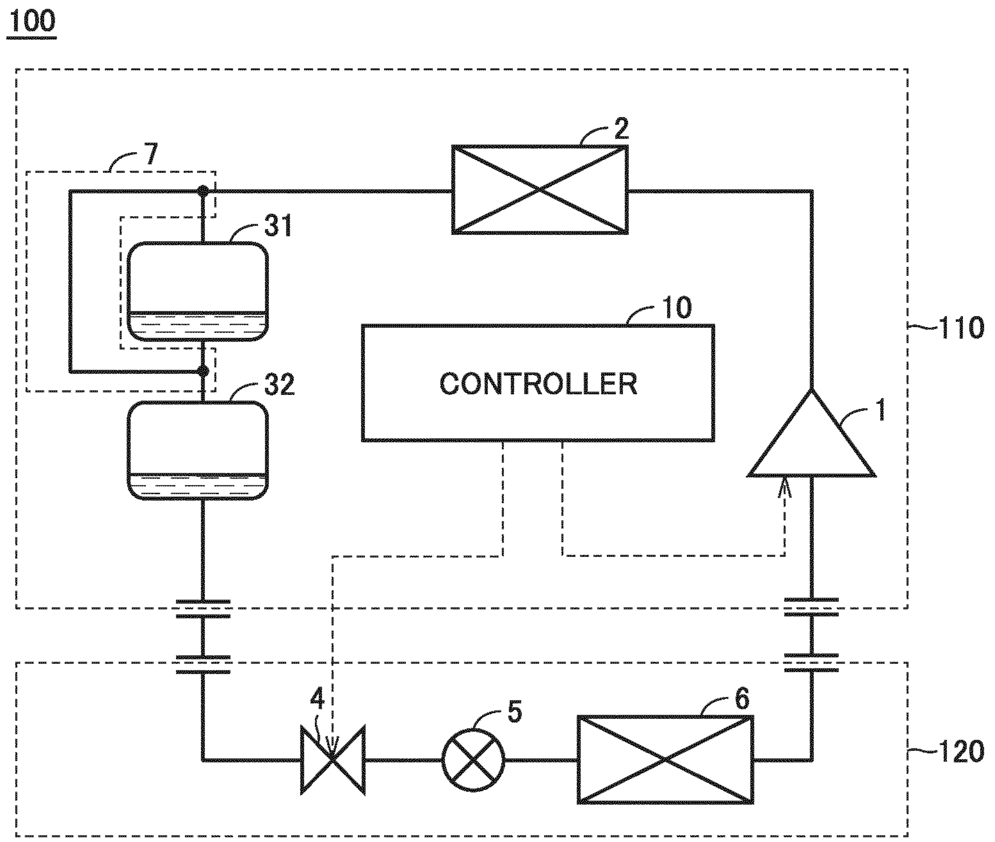
3. The refrigeration cycle apparatus according to claim 2, wherein

   the compressor, the first heat exchanger, the first receiver, and the second receiver are disposed in a first space,
   the first valve, the expansion valve, and the second heat exchanger are disposed in a second space, and
   the specific condition includes a condition that an absolute value of a difference between a temperature of the refrigerant flowing out of the second receiver and a temperature of the first space is smaller than a reference value.

4. The refrigeration cycle apparatus according to claim 2, wherein the specific condition includes a condition that pressure output from the compressor increases in an amount larger than a reference value for a reference time interval.

5. The refrigeration cycle apparatus according to claim 2, wherein the specific condition includes a condition that pressure sucked into the compressor decreases in an amount larger than a reference value for a reference time interval.

FIG.1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31
10
110
CONTROLLER
32
1
4
5
6
120

FIG.2

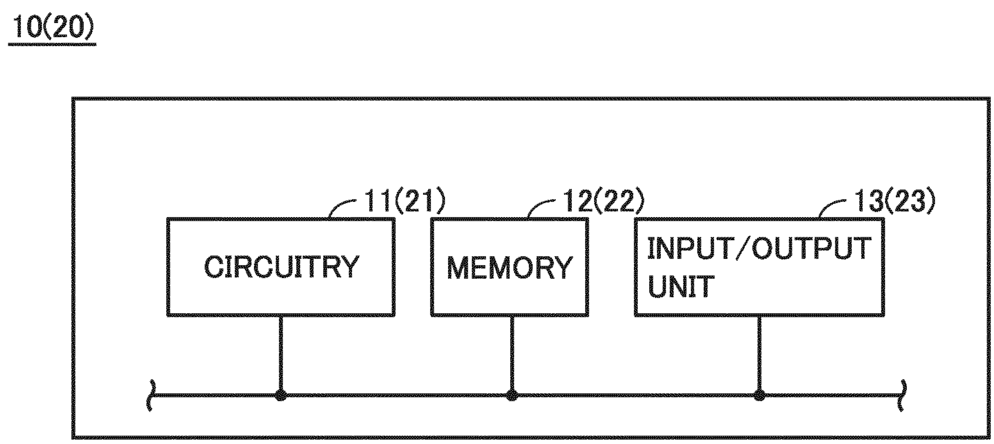

10(20)
11(21)
12(22)
13(23)
CIRCUITRY
MEMORY
INPUT/OUTPUT
UNIT

FIG.3

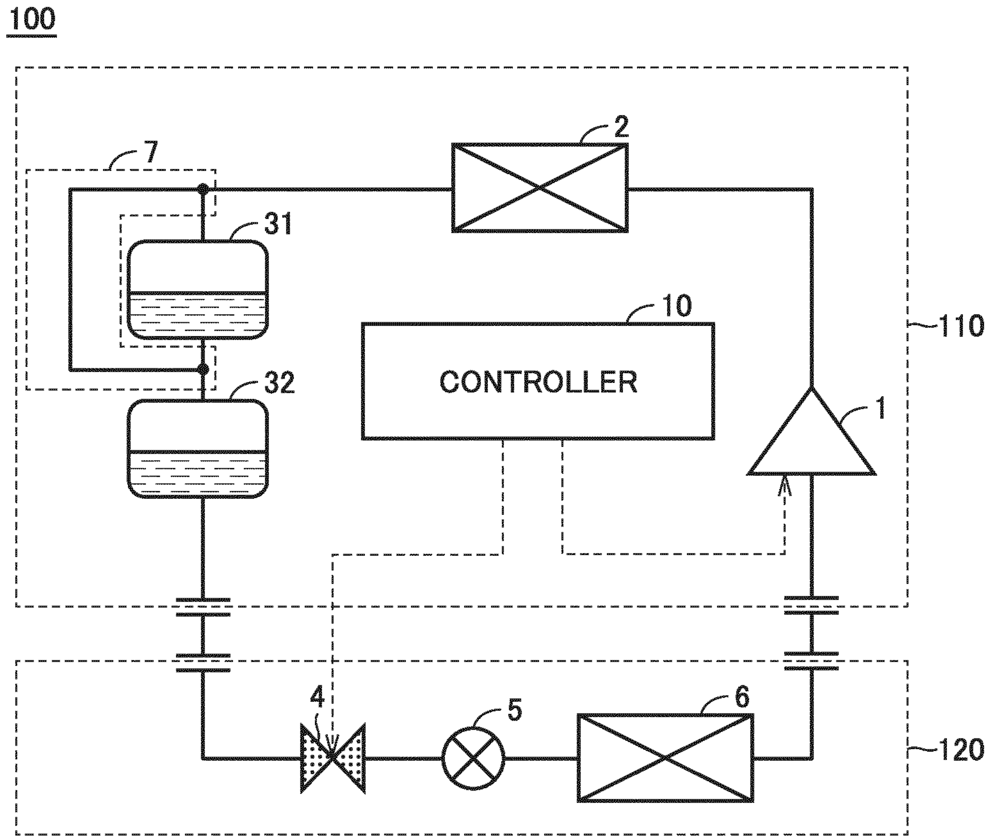


FIG.4

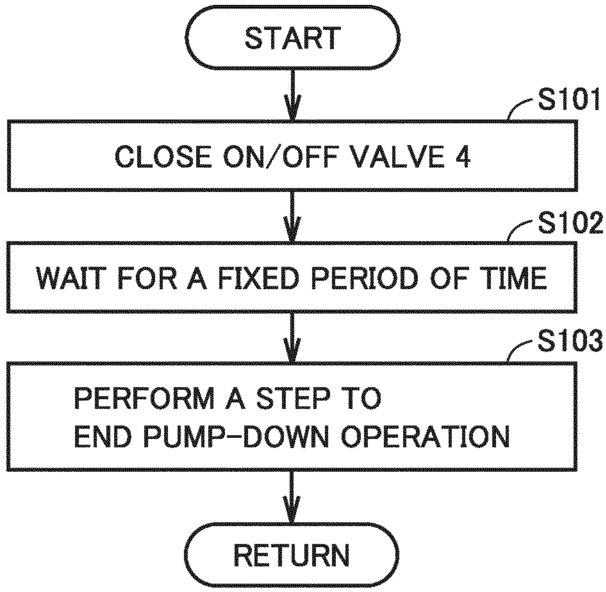

START
S101
CLOSE ON/OFF VALVE 4
S102
WAIT FOR A FIXED PERIOD OF TIME
S103
PERFORM A STEP TO
END PUMP-DOWN OPERATION
RETURN

FIG.5

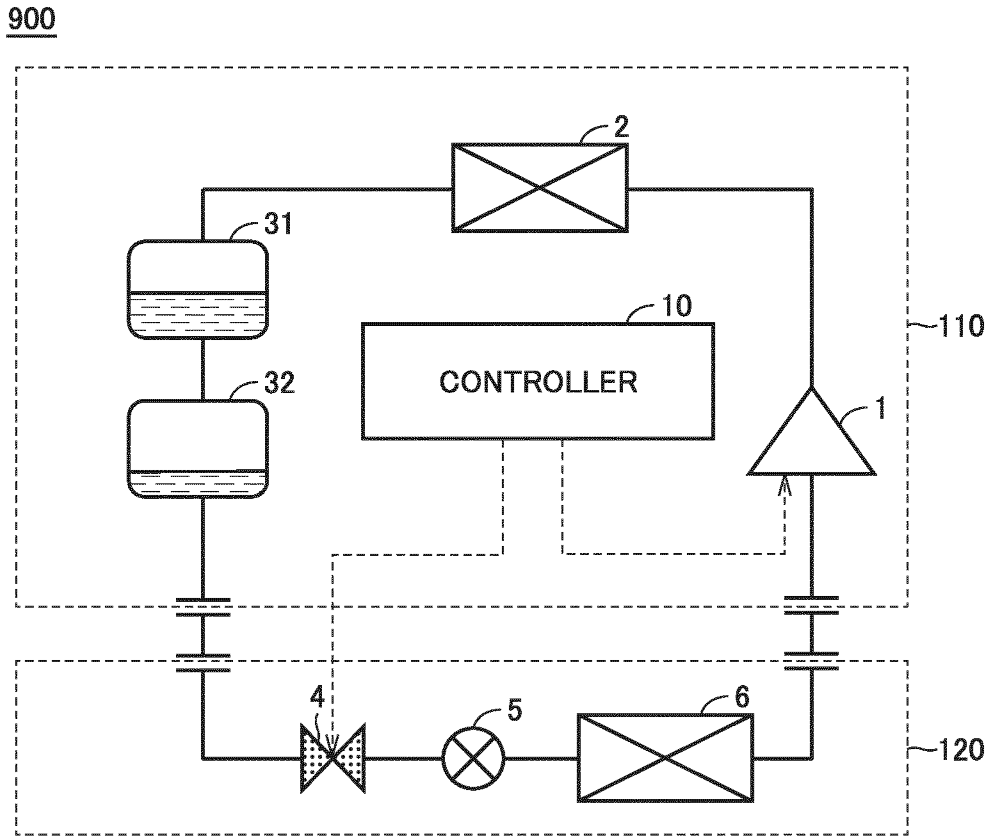
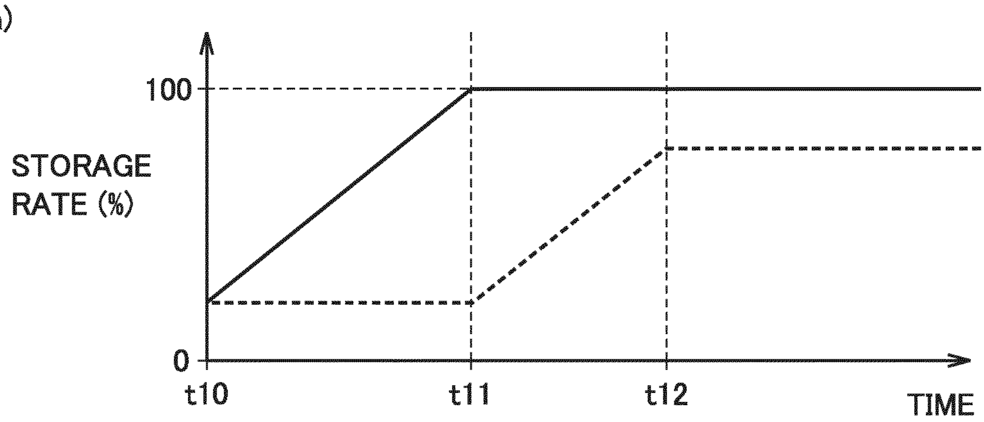


FIG.6

(a)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RATE (%)
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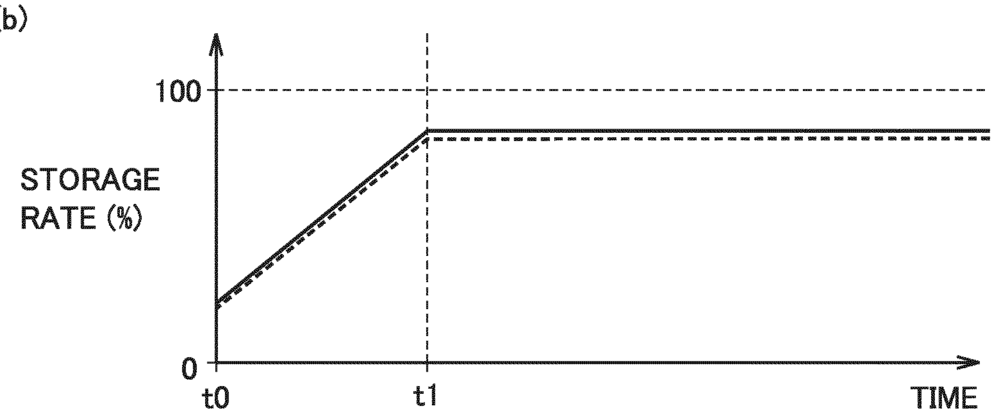
t11
t12
TIME

(b)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STORAGE
RATE (%)
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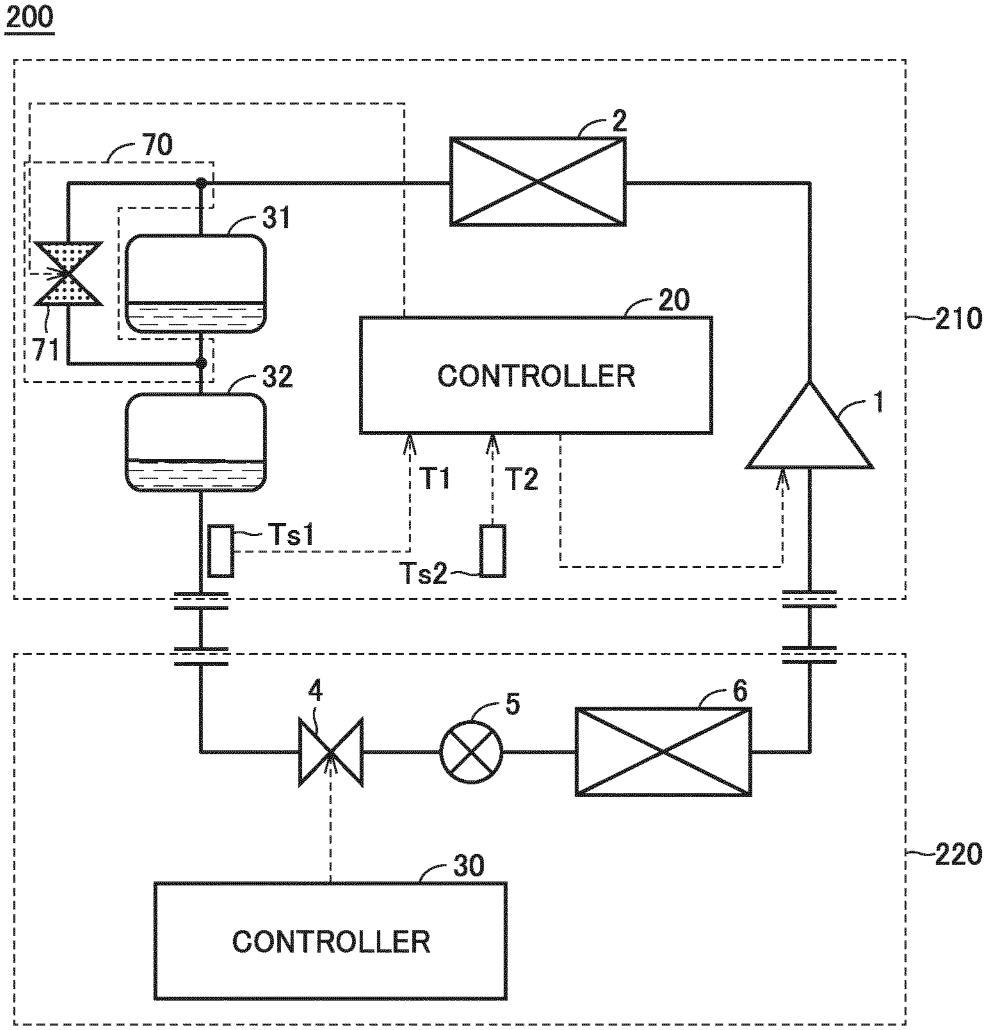
t0
t1
TIME

FIG.7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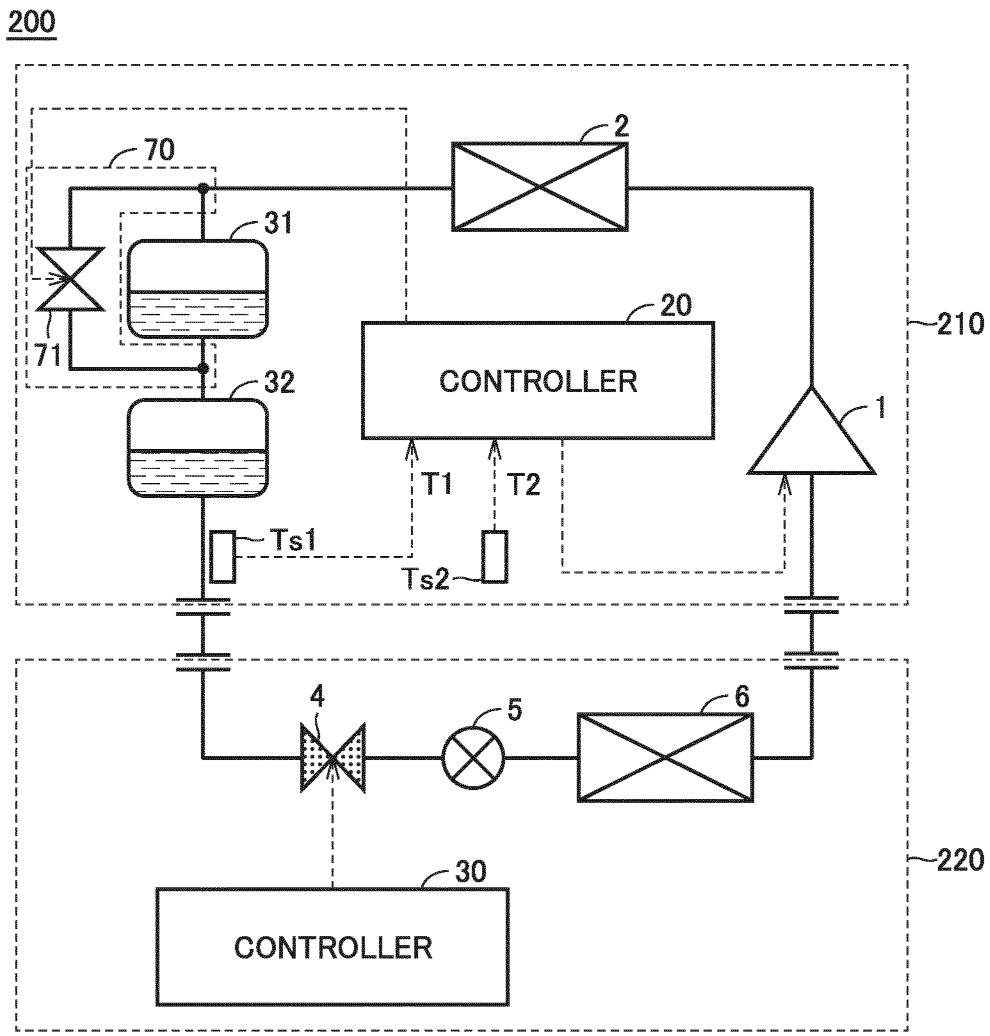
220
30
CONTROLLER

FIG.8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31
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Ts2
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5
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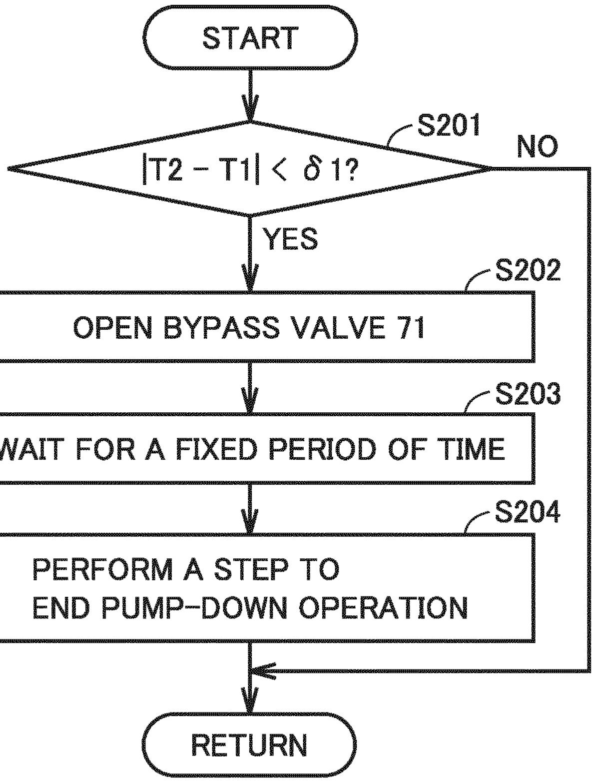
30
220
CONTROLLER

FIG.9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NO
YES
S202
OPEN BYPASS VALVE 71
S203
WAIT FOR A FIXED PERIOD OF TIME
S204
PERFORM A STEP TO
END PUMP-DOWN OPERATION
RETURN

FIG.10

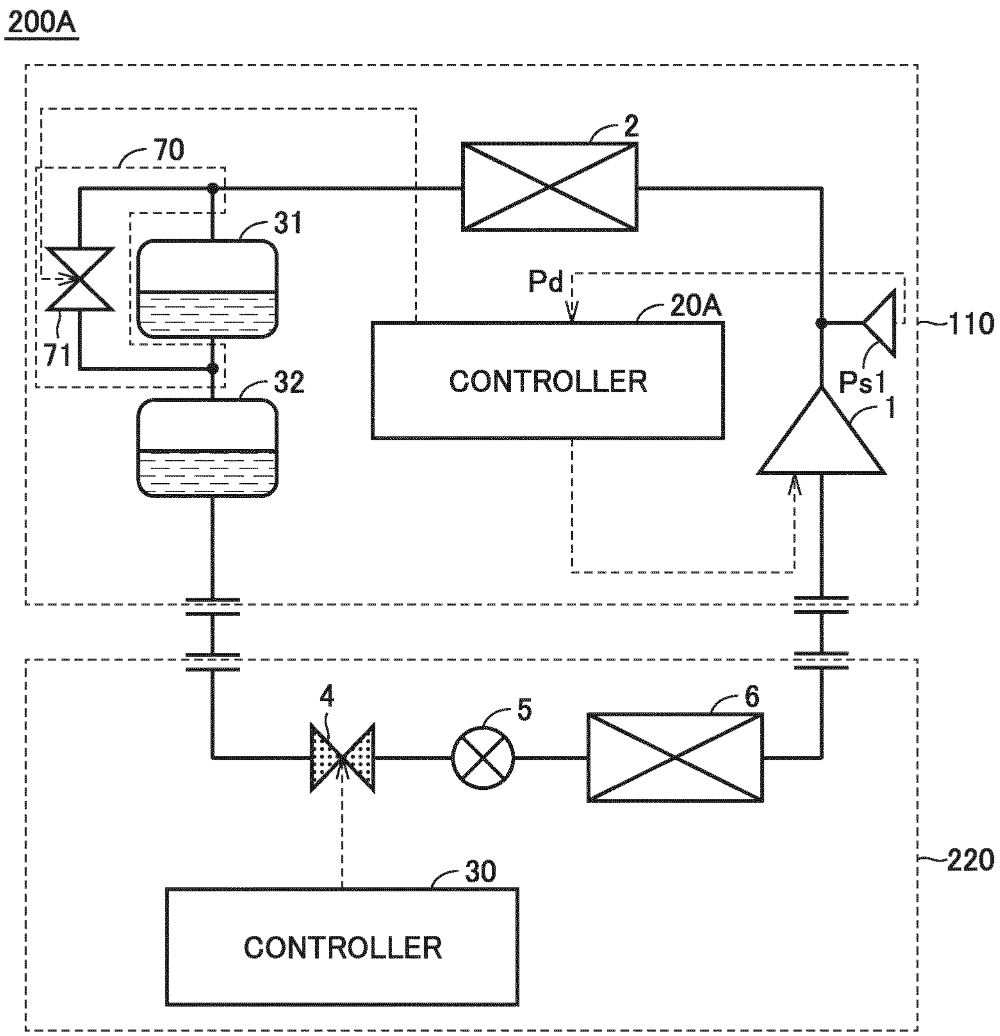

200A
70
2
31
71
Pd
20A
CONTROLLER
110
Ps1
1
32
4
5
6
220
30
CONTROLLER

FIG.11

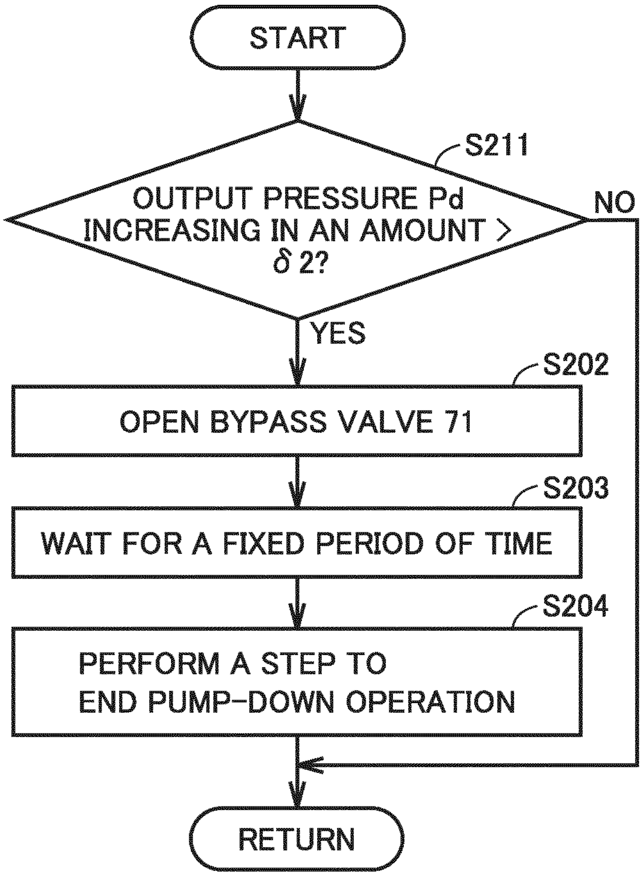

START
S211
OUTPUT PRESSURE Pd INCREASING IN AN AMOUNT > δ 2?
NO
YES
S202
OPEN BYPASS VALVE 71
S203
WAIT FOR A FIXED PERIOD OF TIME
S204
PERFORM A STEP TO END PUMP-DOWN OPERATION
RETURN

FIG.12

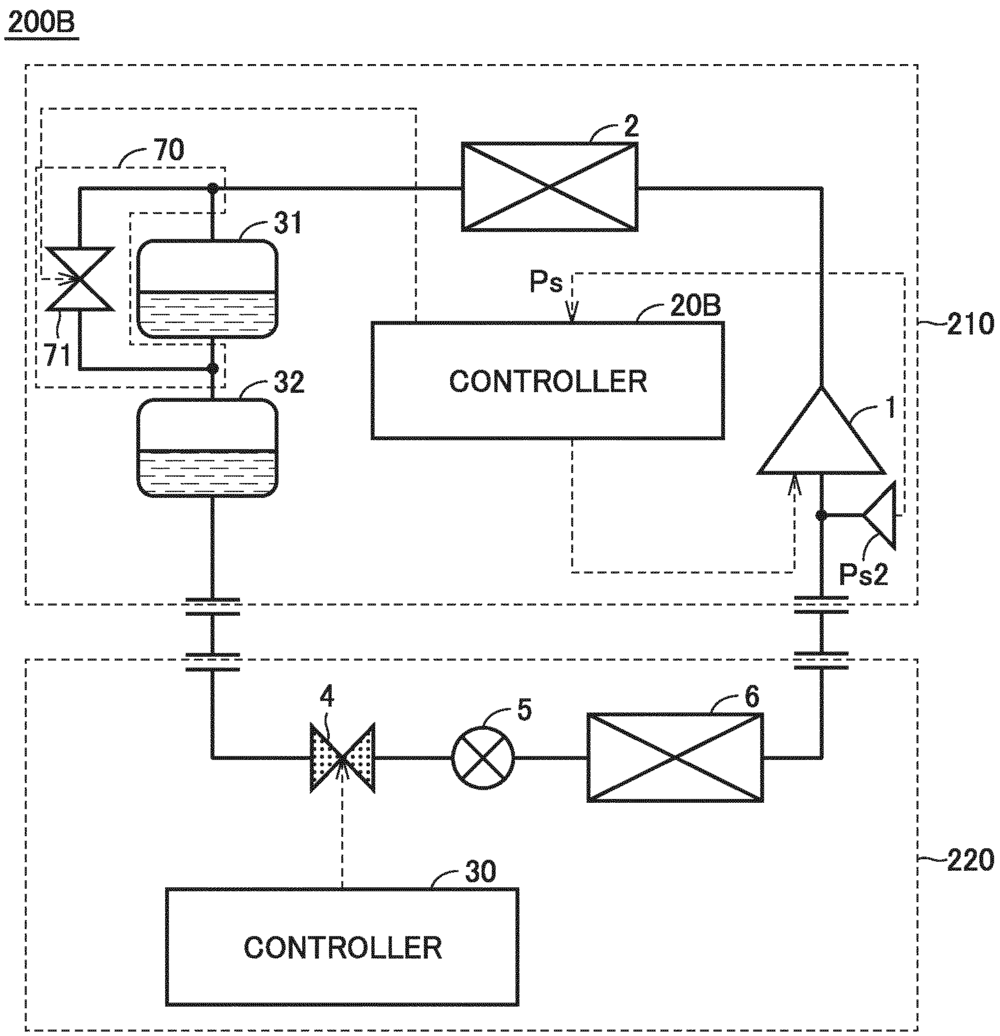
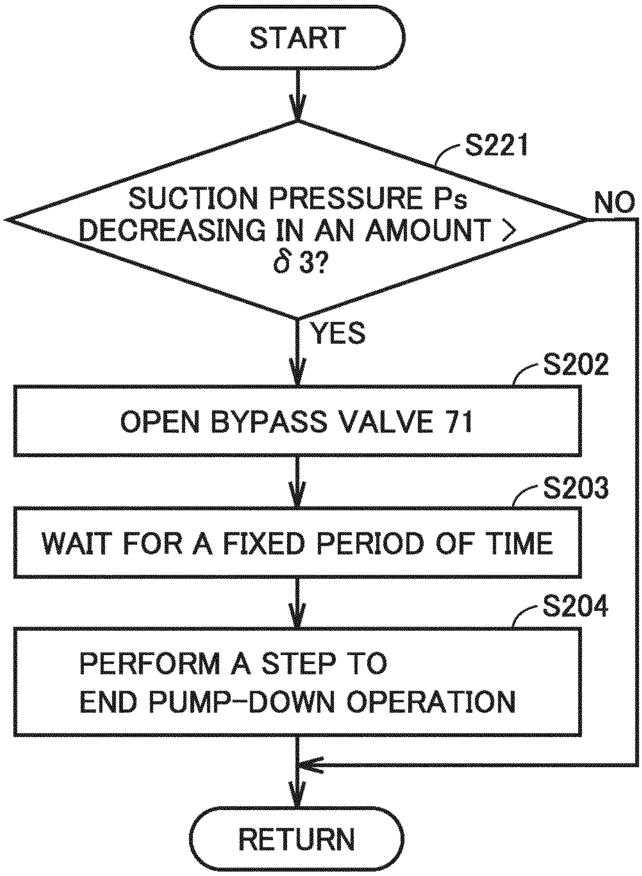

200B
70
2
31
Ps
20B
210
CONTROLLER
71
32
1
Ps2
4
5
6
30
CONTROLLER
220

FIG.13


START
S221
SUCTION PRESSURE Ps DECREASING IN AN AMOUNT > δ 3?
NO
YES
S202
OPEN BYPASS VALVE 71
S203
WAIT FOR A FIXED PERIOD OF TIME
S204
PERFORM A STEP TO END PUMP-DOWN OPERATION
RETURN

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2019/047691

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F25B1/00(2006.01)i, F25B43/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int. Cl. F25B1/00, F25B43/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 5-248717 A (DAIKIN INDUSTRIES, LTD.) 24 September 1993, paragraphs [0001]-[0043], fig. 1-3 (Family: none)	1-2 3-5
Y A	US 5937660 A (LAU, Billy Ying Bui) 17 August 1999, column 1, line 12 to column 8, line 48, fig. 1-25 & JP 9-500713 A, page 8, line 1 to page 14, line 15, fig. 1-20 & WO 1995/003516 A1 & AU 7402994 A & BR 9407152 A & CA 2168095 A & KR 10-1996-0704202 A	1-2 3-5
A	CN 109737623 A (XI'AN JIAOTONG UNIVERSITY) 10 May 2019, paragraphs [0001]-[0017], fig. 1 (Family: none)	1

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search 20.12.2019	Date of mailing of the international search report 07.01.2020
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/047691

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 9410727 B1 (HILL PHOENIX, INC.) 09 August 2016, column 1, line 23 to column 6, line 52, fig. 1, 2 (Family: none)	1-5
A	WO 1999/08053 A1 (ZEXEL CORP.) 18 February 1999, page 1, line 5 to page 8, line 14, fig. 1-3 (Family: none)	1-5
A	WO 2017/061009 A1 (MITSUBISHI ELECTRIC CORP.) 13 April 2017, paragraphs [0001]-[0092], fig. 1-25 & US 2018/0252449 A1, paragraphs [0001]-[0138], fig. 1-25 & CN 108139119 A	1-5
A	JP 6-26716 A (DAIKIN INDUSTRIES, LTD.) 04 February 1994, paragraphs [0001]-[0112], fig. 1-7 (Family: none)	1-5

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REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 62204253 U **[0002] [0003]**